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Doctor interaction behavior, patient participation in value co-creation and patient satisfaction: cross-sectional survey in a tertiary-level hospital from Guangzhou, China

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Value co-creation can be defined as the joint benefit that is created by patients and medical service providers through the integration of their respective resources. Participation and interaction between doctors and patients can generate an outcome that benefits both sides. Relevant studies of value co-creation in the healthcare field are limited. This study established hypotheses to explore the association between doctor interaction behavior, patient participation in value co-creation, and patient satisfaction. A cross-sectional survey was conducted with 637 patients (outpatients and inpatients) at a tertiary-level hospital in Guangzhou, China. The analysis result indicated that doctor interaction behavior could stimulate patient participation in value co-creation then increase patient satisfaction. The standardized total effect, direct effect, and indirect effect were 0.641 (95%CI: 0.055 ~ 0.067), 0.546 (95%CI: 0.044 ~ 0.059), and 0.095 (95%CI: 0.032 ~ 0.166), respectively. Patient participation in value co-creation mediated the relationship between doctor interaction behavior and patient satisfaction. Among the different dimensions of doctor interaction behavior, access, risk assessment and transparency dimensions were associated with positive patient participation in value co-creation. During the treatment process, doctor interaction and patient participation can get satisfying results.

Keywords Value co-creation, Interaction behavior, Patient satisfaction, DART, Patient perception

The concept of value co-creation originated in the commercial field. The lack of a uniform definition has led to the emergence of a range of definitions of value co-creation in recent years. Normann and Ramirez[1] emphasize the significance of the interaction between suppliers and consumers as a fundamental aspect of value creation. Lush and Vargo[2] proposed that firms and consumers can achieve value co-creation through the integration of their respective resources, for example, professional knowledge and skill from the service providers and feedback or experience from the customers. Prahalad and Ramaswamy[3] hold the view that firms create value by co-creating the unique experience with customers rather than only on their own. Value co-creation places an emphasis on the participation and interaction between suppliers and customers in order to reach an outcome that is beneficial to both parties[4]. They put forth a conceptual framework, the DART model[4], comprising four elements that can be utilized to operationalize the concept of value co-creation in the context of business services. Among these, Dialogue (D) can be defined as the tendency of consumers and service providers to communicate, share knowledge, and interact with each other. Access (A) is used to describe that customers can gain the experience and information that relate to products through information technology instead of buying the products or getting the ownership of the products. Risk Assessment (R) is used to describe the potential risks that customers and service providers may be required to confront and address throughout during the process of value co-creation. Transparency (T) refers consumers can obtain lots of information about the products with the

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development of information technology.Consequently, enterprises are no longer able to maintain opaque price and cost, or to generate profits through the information asymmetry with the consumers.

In the field of healthcare, value co-creation can be defined as the joint benefit that patients and medical service providers create by integrating their operational resources (e.g., knowledge and skills) and objective resources (e.g., equipment, drugs, and financial resources)[5]. While there are various definitions of value co-creation, the essential concept is that stakeholders leverage their strengths and advantages, collaborate, co-produce, and co-create value with each other, and ultimately share the value[6]. In the past, doctors were the leaders of medical services. They decided on medical service content and treatment plans while patients could only accept treatments passively and had few opportunities to communicate with their doctors[2]. This situation lacks of communication, interaction, and participation between doctors and patients. Insufficient communication and the absence of information regarding the patient's disease may result in errors in medical treatment, and thus it may lead to disputation and conflict between doctors and patients[7]. However, clinical decision-making is evolving from a physician-centered to one that patients are empowered to participate in their care[8]. With more medical knowledge is available in the internet, the information asymmetry gap between doctors and patients is shrinking. Consequently, patients are now able to discuss and even question disease treatment plans, rather than accepting them passively[2]. Patient participation is essential for achieving optimal treatment effects[5,9]. As Hau et al.[10] noted, while physicians are experts on disease treatment, patients are experts on their conditions and play an important role in improving treatment effects. In addition to the medical services that are provided by the doctors, the support and cooperation of patients are also essential[10]. The cooperation between doctors and patients can facilitate more favourable outcomes in the treatment of disease[10]. Therefore, it is beneficial to introduce value co-creation into the medical field.

Doctors and patients are the main participants during treatment. Participation and interaction of doctors and patients can facilitate the generation of outcomes that are mutually beneficial[4]. This is the content that value co-creation emphasizes and focuses on[4]. In the context of value co-creation, we define doctor behavior as doctor interaction behavior. Doctors have the advantage of medical knowledge and skill, and they have the responsibility to participate in disease treatment. Such interactional behavior encompasses not only the participation of the doctor but also the stimulation and facilitation of patient participation throughout the course of disease treatment. Doctor interaction could be seen as those expressions that perform in the interplay with a patient[10]. Through the development of interaction, the service providers could create opportunities to engage her/himself with customers' practices and to influence them and their outcomes[11]. Usually, patients seek healthcare services with the objective of curing their diseases, improving their health, and having a positive experience of care. Doctors can offer their patients professional guidance and should engage with patients proactively to encourage participation during treatment. A survey of[12] endocrinologists revealed that the lack of formal training in communication skills, including the doctor's attitude and motivation, and the acknowledgement of the doctor's role as a facilitator rather than the sole decision-maker, is one of the barriers to effective shared decision-making between doctors and patients, which in turn affects treatment outcomes. It can thus be posited that the behavior exhibited by doctors in their interactions with patients may serve to stimulate patient participation during the course of treatment.

In the context of value co-creation, we define patient behavior as patient participation in value co-creation. Patient participation is essential for achieving the optimal treatment effect[5]. Furthermore, it constitutes an integral aspect of value co-creation with doctors. In the commercial field, customer participation in a service is defined as a customer's behavior related to the creation and delivery of service offerings[10]. Customer participation is an integral part of the production of a service to co-create value[10]. It is therefore imperative that patients participate in the healthcare service process, as medical service providers cannot effectively deliver the desired service outcome without this input[10]. It has been demonstrated by relevant studies that the performance or interaction behavior of service providers can influence customers' participation during the provision of a service. A relevant study[13] conducted an interview with the leaders of the public transport sector and members of the community in Scotland. The results demonstrated that the provision of opportunities for participation and communication, as well as the empowerment of community members by the supplier, influenced customers' motivation to participate in value co-creation[13]. In the medical field, doctors and patients are major participators in the treatment process, with a close and interdependent relationship. Patients place their treatment expectations on doctors, and therefore, doctors' performance, reaction, and interaction play an important role in patients' subsequent behavior. Related studies indicated that patient participation in value co-creation was influenced by the factors from medical service providers, such as the willingness and behavior of doctors to facilitate patient participation, or their interpersonal communication skills with patients[14]. This also demonstrated that doctor interaction behavior may stimulate patient participation during the course of treatment.

Meanwhile, when patients perceived positive interaction behavior from their doctors, they demonstrated active participation in value co-creation, such as the sharing of information and the assumption of corresponding responsibility[10,15]. However, some studies have proposed that there is a discrepancy in perception between doctors and patients. Doctors usually have high self-perception about promoting patients' participation in treatment while patients have a low perception about this, thus it may influence patients' performance during treatment[14]. Relevant research demonstrated that a positive response from healthcare providers to patients' needs and requests can increase patients' motivation to participate in safety, whereas a negative attitude of the providers can discourage patient participation[16]. Then, it seems that when patients perceive doctor interaction behavior, they may participate in treatment actively, such as communicating with or cooperating with the doctors.

Therefore, we proposed the following Hypothesis in light of the preceding literature review. Specifically, Hypothesis 1(H1): Doctor interaction behavior is positively related to patient satisfaction.

Patient satisfaction can be defined as the state of pleasure or happiness that patient experiences when using a health service[17]. It is an important and common performance indicator that assesses the quality of healthcare service provision[18]. Meanwhile, patient satisfaction is an essential part of the quality of medical care[19]. During treatment, doctor-patient value co-creation, namely doctor interaction and patient participation in value co-creation, can have a beneficial influence on both doctors and patients. Relevant studies show that doctors provide patients the opportunity to express their feelings and participate in discussing treatment plans, namely patient participation in value co-creation, which could promote mutual understanding and trust, enhance patient adherence, and ultimately improve treatment effect and patient satisfaction (both physical and mental satisfaction)[4,10,20,21]. Furthermore, patient's high satisfaction also contributed to a good treatment experience, and a high level of trust in the doctor's abilities, which may also have a beneficial impact on the doctor's sense of fulfilment and achievement in their work[22,23]. We proposed the following Hypothesis based on the forward introduction: Hypothesis 2(H2): Patient participation in value co-creation may increase patient satisfaction.

The aforementioned information indicates that doctor-patient co-creation, namely doctor interaction and patient participation in value co-creation during treatment are beneficial to increasing patient satisfaction. Meanwhile, patient participation in value co-creation is influenced by doctor interaction behavior. A relevant study indicated that in the context of healthcare service, the interaction expressed by a service frontline plays a critical role in activating customer participation, which in turn leads to a higher level of perceived value[10]. Thus, patient participation in value co-creation may be considered as the mediator between doctor interaction behavior and patient satisfaction. Therefore, we proposed the following Hypothesis: Hypothesis 3(H3): Patient participation in value co-creation mediates the influence of doctor interaction behavior on patient satisfaction.

Currently, evidence about value co-creation in the healthcare field is limited, with many studies validated in the commercial field. Doctors and patients are the main participants during treatment. Participation and interaction have the potential to generate outcomes that are beneficial to both sides, including improvements in patient satisfaction, treatment efficacy, and the quality of medical care, which can be defined as co-created value. Previous studies have primarily focused on examining behavior from a single perspective, either that of the doctor or the patient. Additionally, various models have been proposed to describe doctor-patient communication. These include the Four Habits Model[24], the SEGUE Framework[25], and the Six-stage extended model[26], which provides a guideline for daily communication practice. However, the majority of them focus on the behavior of medical service providers, such as doctors or nurses, and patient behavior gains limited attention. In this study, we developed the hypotheses by considering both the doctor's and the patient's behavior within the context of value co-creation, which advocates interaction and participation of service providers and customers. This is expressed in Hypothesis 1(H1): Doctor interaction behavior is positively related to patient satisfaction, Hypothesis 2(H2): Patient participation in value co-creation may increase patient satisfaction, and Hypothesis 3(H3): Patient participation in value co-creation mediates the influence of doctor interaction behavior on patient satisfaction. A cross-sectional survey will be conducted in a tertiary-level hospital to test the hypotheses and explore the relationship between the doctor's interaction behavior as perceived by the patient, the patient's participation in value co-creation, and patient satisfaction primarily. According to the analysis results, we proposed relevant strategies and suggestions to stimulate doctors' interaction behavior and patients' participation behavior, which will be beneficial to improving patient satisfaction and treatment effect, shrinking doctor-patient information asymmetry, and increasing the quality of medical care.

Methods

Participants

The participants were recruited from a tertiary-level hospital in Guangzhou, China, between October and November 2019.The inclusion criteria were (1) outpatients and inpatients who had visited or accepted medical treatment service at this hospital in the last week, (2) 18 years or older, and (3) able to express their opinions. All patients who visited the hospital and met our criteria were invited to participate in the questionnaire investigation. Patients with dementia, psychosis, or cognitive or communicative impairments were excluded. The questionnaires were distributed and collected face to face by trained investigators. All respondents were required to complete the questionnaire independently. Investigators provided clarification if the respondents had difficulties understanding the questions. The questionnaires were double-checked by investigators to ensure no data was missing.

According to the sample calculation method provided by Kandell[27], each item should be answered by at least 10 respondents. Our questionnaire contained 48 items and considering 20% censoring rate, a sample size of 490 was confirmed (10 individuals $\times$ 48 items + 10% $\times$ 48 items). The outpatient and inpatient departments were surveyed according to the following department classification: internal medicine, surgical, and others. Around 164 participants were expected to be recruited from inpatients and outpatients, respectively. Moreover, about 28 participants were expected to be recruited from each of the two classified departments. Additionally, about 14 participants were expected to be recruited from the two sub-departments under the two classified departments for inpatients and outpatients, respectively.

A total of 675 questionnaires were distributed, and 668 were subsequently collected. The data from 31 participants were excluded for two reasons: (1) missing responses to more than 10 items of the questionnaire (a valid questionnaire was defined as one in which $\geq$ 80% of the items had been completed; an invalid questionnaire was defined as one in which $\geq$ 20% of the items had missing responses) or (2) the respondent had not responded to the questionnaire seriously (e.g., a majority of the items ($\geq$ 80% of items) in the questionnaire were scored as strongly agree or strongly disagree, otherwise the scale would have serious floor or glass floor effect, which will influence the analysis accuracy)[28]. Consequently, the data from 637 valid questionnaires were analyzed in this study.

Measures

Ascertainment of doctor interaction behavior and patient participation in value co-creation

Self-developed Doctor Interaction Behavior Evaluation Scale and Patient Value Co-creation Behavior Scale were employed to assess doctor interaction behavior and patient participation in value co-creation behavior, respectively. The reliability and validity of these two scales have been previously confirmed in the previous studies[29,30]. All items in these two scales were evaluated on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) according to patients' actual perception (patient evaluate the doctor who is mainly responsible for their health and disease treatment during the last week, for example, outpatient evaluate doctor's behavior who they visited last week; inpatient evaluates the behavior of doctor who is responsible for their health during hospitalization and who is called "主治医生" [attending doctor in Chinese]) and self-reported. Additionally, these two scales were developed in accordance with the DART model[4]. Because it defines and classifies value co-creation behavior concisely and systematically, many scholars have used the DART model to develop relevant scales to measure value co-creation activities and behavior[2]. However, most measures of value co-creation have been validated in the commercial field. We introduced it into the healthcare field and constructed measurement scales in the previous study among value co-creation background. The four dimensions, namely Dialogue, Access, Risk assessment, and Transparency, consist the DART model. In light of the findings of the literature review, the characteristics of medical services, expert consultation, and discussion among research groups, we put forth the following definition of the DART model in the medical field as follows: Dialogue means communication, and knowledge sharing between doctors and patients; Access means doctors and patients obtain medical services and information about disease treatment through relevant channels or tools; Risk assessment means doctors and patients evaluate and manage the potential danger during treatment; and Transparency means treatment information transparency and emphasizing information authenticity, information disclosure[29,30]. The dimension scores are calculated by summing the corresponding item scores, and the total score of the two scales is the summary of all items' scores. A higher total score indicates greater doctor interaction and more actively patient participation in value co-creation respectively of the two scales. These methods about calculating the dimension score and total score of the scale have been used in relevant study in the field of healthcare field, such as the Jefferson Scales of Empathy which has been widely used to measure physician and medical students' empathy[31,32]. Please also check the screenshot of the book. The items in this study can be found in the supplementary material (Table S1).

Ascertainment of patient satisfaction

Patient satisfaction was assessed based on self-reporting using a single question on satisfaction with treatment services provided by doctors. Response for this item was a 5-point Likert scale (1, very dissatisfied; 5, very satisfied). The questionnaire is provided in the supplementary material (Table S1).

Background characteristics

Information about the participant's background characteristics, which includes the socio-economic status of patients, namely age, gender (male or female), current marital status (unmarried or married), educational level (junior high school and below or more than junior high school), and monthly income (< = 4,000 RMB, or > 4000 RMB) was collected.

Statistics analysis

Mean imputation method was used to deal with the missing data in this study. Path analysis was conducted using the PROCESS version 4.0 (Model 4), installed in the SPSS version 20.0, to examine the proposed hypotheses. The PROCESS program has been widely used since it was first proposed by Hayes[33]. It used Bootstrap Confidence Interval method to analyze mediation effect. Furthermore, it is a member of a class of procedures, known as resampling methods[33]. One of its advantage is that the assumptions on which the method depends are less restrictive, and more easily checked than those on which conventional methods depend. For instance, it does not require restrictive, and often unrealistic, assumptions (e.g., about measurements being normally distributed)[34]. Moreover, different kinds of modelling procedures were developed to meet the need of path analysis[33]. In this study, the model 4 procedure is used to analyze the mediation effect of patient participation in value co-creation.

Ethical approval

The research protocol and informed consent were approved by the ethical committee of Southern Medical University. All participants provided the written informed consent. All methods were conducted in accordance with the relevant guidelines and regulations.

Results

Social-demographic characteristics

Among the 637 participants, 383 (60.13%) were outpatients and 254 (39.87%) were inpatients, 322 (50.55%) were men, the average age of the participants is 37.04, and most (73.63%) received junior middle school education or above. In terms of the monthly income, 46.94% of the participants reported an income of less than 4,000 yuan, while 53.06% reported an income of more than 4,000 yuan. For further details, please refer to Table 1.

Path analyses of hypotheses

After controlling the covariates, the standardized coefficients of doctor interaction behavior on patient satisfaction in model 1 had positive significance ($\beta = 0.641$,95%CI: 0.055 ~ 0.067). The analysis result of model 2 also showed that doctor interaction behavior was positively related to patient participation in value co-

	Frequencies	Percentage (%) /Mean ± SD
Type		
Outpatient	383	60.13
Inpatient	254	39.87
Gender		
Male	322	50.55
Female	315	49.45
Age		37.04 ± 14.71
Marriage		
Unmarried	241	37.83
Married	396	62.17
Educational background		
Junior high school and below	168	26.37
More than junior high school	469	73.63
Monthly income		
<=4,000 yuan	299	46.94
>4,000 yuan	338	53.06

Table 1. Summary of the demographic characteristic of the participants ($N = 637$). SD = standard deviation.

		Model 1			Model 2			Model 3		
Predictor variables	**Measurements**	**β**	**t**	***P*** **(95%CI)**	**β**	**T**	***P*** **(95%CI)**	**β**	**t**	***P*** **(95%CI)**
Doctor interaction behavior	Continuous measurements	0.641	20.60	< 0.001 (0.055 ~ 0.067)	0.647	22.00	< 0.001 (0.432 ~ 0.516)	0.546	13.32	< 0.001 (0.044~0.059)
Patient participation in value co-creation	Continuous measurements							0.146	3.50	0.001 (0.008~0.030)
Covariates										
Age	Continuous measurements	0.028	0.67	0.503 (-0.005 ~ 0.011)	-0.119	-3.03	0.003 (-0.150~ -0.032)	0.045	1.09	0.275 (-0.004 ~ 0.013)
Gender	Male = 1 Female = 2	0.003	0.09	0.925 (-0.171 ~ 0.188)	-0.021	-0.69	0.490 (-1.771 ~ 0.849)	0.006	0.19	0.849 (-0.161~0.195)
Current marital status	Unmarried = 1 Married = 2	-0.036	-0.92	0.357 (-0.334 ~ 0.121)	0.009	0.23	0.817 (-1.464 ~ 1.856)	-0.037	-0.96	0.336 (-0.336~0.115)
Educational level	Junior high school and below = 1 More than junior high school = 2	0.062	1.60	0.110 (-0.047 ~ 0.458)	0.188	5.11	< 0.001 (2.955 ~ 6.640)	0.035	0.88	0.377 (-0.140~0.370)
Monthly income	<=4,000 yuan = 1 > 4,000 yuan = 2	-0.0004	-0.01	0.991 (-0.194 ~ 0.192)	0.080	2.50	0.013 (0.382 ~ 3.201)	-0.012	-0.36	0.720 (-0.227~0.157)
R		0.64			0.69			0.65		
R^2		0.41			0.47			0.42		
F		72.51^{***}			93.41^{***}			65.02^{***}		

Table 2. Model and hypotheses testing. Analysis results shown in the table were after controlling covariates by using Process (Version 4.0) installed in SPSS; "**" $p \leq 0.05$, "***" $p \leq 0.01$; β, Standardized coefficients; R^2, R square; 95% CI, 95%confidence interval, ADL, Activities of Daily Living. Model 1 was used to test total effect: the independent variable was doctor interaction behavior and the dependent variable was patient satisfaction; Model 2 was used to test the direct effect of doctor interaction behavior on patient participation in value co-creation behavior: the independent variable was doctor interaction behavior and the dependent variable was patient participation in value co-creation; Model 3 was used to test the direct effect of doctor interaction behavior and patient participation in value co-creation on patient satisfaction, respectively: the independent variables were doctor interaction behavior and patient participation in value co-creation, the dependent variable was patient satisfaction.

creation (β = 0.647,95%CI: 0.432 ~ 0.516). In model 3 (Table 2), both doctor interaction behavior and patient participation in value co-creation were found to have a positive influence on patient satisfaction (β = 0.546, 95%CI: 0.044 ~ 0.059; β = 0.146,95%CI: 0.008 ~ 0.030).

The standardized indirect effect value was 0.095(95%CI:0.032 ~ 0.166), indicating that doctor interaction behavior influenced patient satisfaction through patient participation in value co-creation. Namely, patient

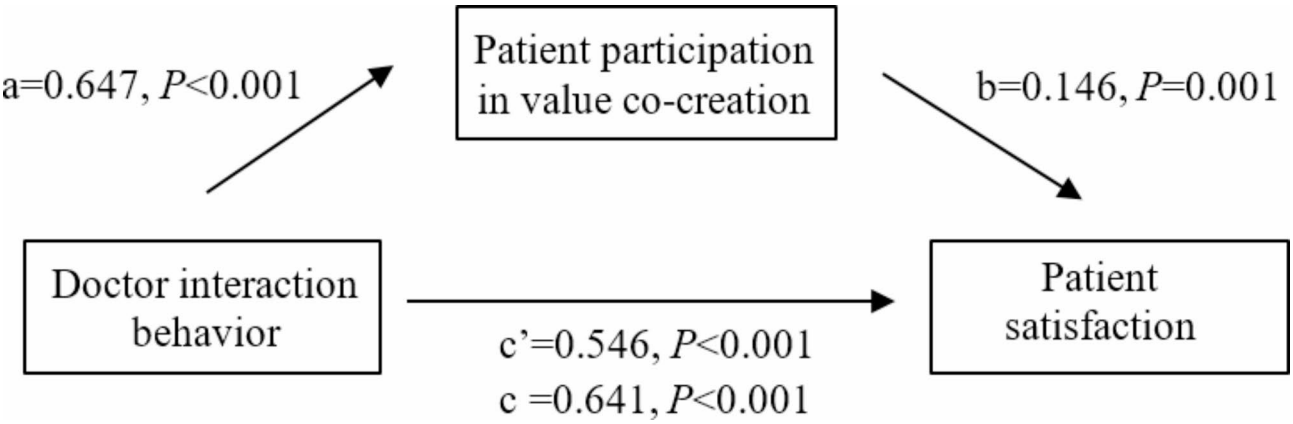

Fig. 1. Regression coefficients between doctor interaction behavior, patient participation in value co-creation and patient satisfaction. Note: a = direct effect from doctor interaction behavior on patient participation in value co-creation; b = direct effect from patient participation in value co-creation on patient satisfaction; a*b = indirect effect; c'=direct effect from doctor interaction behavior on patient satisfaction; c = total effect=|a|*|b|+|c'|.

	Standardized Effect Values	95%CI
Total effect	0.641	0.055 ~ 0.067
Direct effect	0.546	0.044 ~ 0.059
Indirect effect	0.095	0.032 ~ 0.166

Table 3. Test result about mediating effect of patient participation in value co-creation. 5,000 bootstrap samples.

participation in value co-creation worked as a mediator between doctor interaction behavior and patient satisfaction. Therefore, the three hypotheses proposed in this study were validated (Table 3).

Subsequently, we examined the influence of different dimensions of doctor interaction behavior on patient participation in value co-creation in order to understand which kinds of doctor interaction behavior are associated with positive stimulation of patient participating in value co-creation. After controlling the covariates, the results demonstrated that, with the exception of the dialogue dimension, the remaining three dimensions of doctor interaction behavior were associated with positive patient value co-creation participation (Table 4).

Discussion

In addition to the medical services and skills provided by doctors, patients' active participation is also essential for disease treatment[8]. Value co-creation emphasizes the participation and interaction of suppliers and customers, with the objective of reaching an outcome that is beneficial to both parties[4]. The principal participants in the treatment process are the doctors and patients. Doctors' interaction and patients' participation can result in the generation of beneficial outcomes, such as increasing the quality of medical care that benefits both sides[4]. It is beneficial to introduce value co-creation into the medical field. The concept of value co-creation has its origins in the commercial field. And relevant studies in the healthcare field is limited. In this study, we developed hypotheses, namely Hypothesis 1(H1): Doctor interaction behavior is positively related to patient satisfaction, Hypothesis 2(H2): Patient participation in value co-creation may increase patient satisfaction, and Hypothesis 3(H3): Patient participation in value co-creation mediates the influence of doctor interaction behavior on patient satisfaction. To initially explore the veracity of these research hypotheses, a cross-sectional survey was conducted in a tertiary-level hospital. Relevant strategies and suggestions were proposed to stimulate doctors' interaction behavior and patients' participation to increase patient satisfaction and the quality of medical care. After adjusting covariates, the analysis results indicated that all the hypotheses were supported. This demonstrated that it is appropriated to introduce value co-creation theory into the medical field. Meanwhile, when patient perceived doctor's interaction behavior it could increase their satisfaction, and patient participation in value co-creation mediated this relationship. Meanwhile, different kinds of doctor interaction behavior that perceived by patients had different influence on patient participation in value co-creation. Among them, dimensions of access, risk assessment, and transparency could stimulate patient participation in value co-creation.

The analysis results showed that Hypothesis 1(H1) was confirmed, namely, doctor interaction behavior perceived by the patient was correlated with positively patient participation in value co-creation and could improve patient satisfaction. These results were consistent with previous studies[10,12,14–16,20,21]. It has been demonstrated that when doctors pay more attention to patients, provide care and explanations that address patients' feelings and needs, and communicate information about treatment clearly and patiently, patients'

Different dimensions of doctor interaction behavior	β	t	*P* (95%CI)	Collinearity Statistics	
				Tolerance	VIF
1. Dialogue	0.071	1.29	0.197	0.27	3.64
2. Access	0.253	4.19	< 0.001	0.23	4.41
3. Risk-assessment	0.176	3.26	0.001	0.28	3.55
4. Transparency	0.214	4.19	< 0.001	0.32	3.17
Covariates					
Age	-0.125	-3.2	0.001	0.55	1.83
Gender	-0.021	-0.71	0.478	0.95	1.05
Current marital status	0.013	0.35	0.725	0.63	1.59
Educational level	0.186	5.09	< 0.001	0.62	1.61
Monthly income	0.086	2.7	0.007	0.82	1.21
R^2	0.48				
R^2_{adj}	0.47				
F	64.61***				

Table 4. Influence of different dimensions of doctor interaction behavior on patient participation in value co-creation ($n = 637$). Analysis results shown in the table were after controlling covariates; the collinearity statistics results show that the tolerance values of all variables are greater than 0.20 and the VIF values are less than 5, indicating that the covariance is moderated "**" $p \leq 0.05$, "***" $p \leq 0.01$; β, Standardized coefficients; R^2, R square, $R^2_{adj,}$ Adjusted R square.

comprehension is enhanced, leading to an improvement in their satisfaction over the course of treatment[35,36]. Furthermore, doctor interaction behavior, including the provision of alternative treatment plans and the solicitation of patients' needs, concerns, and advice, can facilitate patient to participate in value co-creation, such as positive communication, feedback, treatment adherence, and self-management[37]. Meanwhile, these could be seen as the important component of person-centred care that includes providing patients with greater decision-making power, more choices and integrating the environment with patients' unique physical, psychosocial, cultural, and emotional needs[38].

The results of the study demonstrated that patient participation in value co-creation was positively related to patient satisfaction, thereby confirming Hypothesis 2 (H2). It is consistent with the findings of related studies[4,10,20,21]. Patients who participate in treatment, such as engaging in treatment discussion or care decisions with doctors, communicating personal preferences, needs, or feedback to doctors, conducting good self-monitoring, and so on, is associated with good health outcomes, such as reducing mortality, increasing physical and mental health, and reducing healthcare costs[39,40].

Patient participation in value co-creation played as a mediator between the relationship of patient perceived doctor interaction behavior and patient satisfaction. Hypothesis 3(H3) was confirmed. The results of this analysis provide further insight into the reasons behind the positive influence of doctor interaction behavior on patient satisfaction. There is a discrepancy between the perception of patients and the self-rated behavior of doctors[14,37]. Patients would be stimulated to participate in treatment actively when they perceive positive interaction attitude or behavior from their doctors, then gain satisfied treatment experience and improve their satisfaction[10,15]. The analysis results demonstrated in this study indicated that during treatment, both doctors and patients work or corporate together could get satisfied consequences. Meanwhile, the standardized value of the indirect effect is 0.092, which is smaller than the direct effect (standardized effect values = 0.549). Probably because during treatment, patient perceived doctor interaction has the stronger and more direct relationship with patient satisfaction. Furthermore, additional factors or variables may exert an influence on patient satisfaction during treatment, which may have a confounding influence with each other and can be further explored in the future studies. Moreover, it is important to acknowledge that that not all patients are capable or willing to participate in value co-creation or disease treatment. It is related to patients' ability, awareness or self-efficacy. It has been demonstrated in related studies that patients who search for medical information or knowledge in advance can increase their confidence and active participation in disease treatment or management[41]. High self-efficacy is also contributed to patient's active self-management and participation in disease treatment[42,43]. Consequently, patients may enhance their capacity for active involvement in their own care and disease treatment by acquiring or learning further health or medical knowledge.

There is a difference or gap between patient perception and doctor self-evaluation. Relevant research found that doctors evaluate themselves in the high score about promoting patient participation, whereas patients reported the low level[14]. A study of doctors' service attitudes revealed that 83.27% of doctors self-evaluated that they would provide their patients with clear explanations until they fully understand. However, only 63.49% of patients believed that doctors would conduct this behavior[44]. Additionally, 64.73% of patients reported that they received encouragement from their doctors, whereas doctors' self-evaluated this rate was 82.21% [45]. Self-developed Doctor Interaction Behavior Evaluation Scale was used in this study, it included four dimensions, namely Dialogue, Access, Risk assessment, and Transparency. Patients evaluated their doctors' behavior in

accordance with their actual perception. We analyzed the relationship between different dimensions of doctor interaction behavior and patient participation in value co-creation in order to find out which kinds of doctor interaction behavior perceived by patient can positively stimulate patient participation in value co-creation. The results of the analysis demonstrated that the dimensions of access, risk assessment, and transparency of doctor interaction behavior were associated with positive patient participation in value co-creation, and their standardized coefficients were similar. However, no statistically significant association was found between the dimension of dialogue and patient participation in value co-creation. In our study, the dimensions of access, risk assessment, and transparency not only emphasize the communication of daily treatment and the sharing of information from doctor to patient, but also focus on the communication of detailed treatment information and the opportunity for patients to participate in discussions about their treatment with one another[30]. For example, the doctor designs the treatments plans based on the patient's need and provides patient the opportunity to choose in access dimension; doctor encourages patient to follow treatment prescription and informs the negative influence if not in risk assessment dimension; the doctor tells patient about the reasons and costs if large-scale inspections are needed or expensive medications are needed during treatment in transparency dimension. The dimension of dialogue mainly focus on daily treatment communication process, such as doctor guiding patient to provide appropriate information, explaining the disease condition clearly[30]. The analysis results also showed that with the improvement of living standard and health awareness, patients pursue high-quality medical service in addition to the disease treatment, such as receiving positive service attitude and behavior from medical staff and having positive medical experience[45].

In light of the findings of the analysis we propose related strategies and measures to promote doctor interaction behavior and enhance patient participation in value co-creation. The development of effective communication skills is an essential component of becoming a good doctor[46]. For the doctors' part, in addition to medical skill training, they should undergo training in clinical and communication skills in order to ensure that patients feel respected and cared for. This could facilitate patient satisfaction, participation and cooperation[46,47]. For instance, the doctor communicates or explains medical knowledge and detailed information to patients more understandably and patiently; shows kind and empathy towards patients when they have questions or concerns about disease treatment; designs the treatment plans based on patients' needs and situations and invites them to discuss together. Furthermore, patients should take the initiative to collect and understand knowledge related to disease treatment through the Internet, news, and health lectures to empower themselves to participate in discussing treatment plans with doctors. Patients should also take the initiative to consult their doctors to verify the accuracy of information that learned by themselves above and improve their ability to identify and deal with diseases with confidence, as medical information obtained through online platforms may not be accurate[48].

Strengths and limitations

Our study introduced value co-creation theory into the healthcare field and explored the relationship between doctor interaction behavior, patient participation in value co-creation and patient satisfaction. The analysis results revealed that all hypotheses were confirmed, which indicates that it is appropriate to introduce value co-creation into the medical field. Doctors interact with patients and stimulate patients to participate in disease treatment. The cooperation between doctors and patients can improve the treatment effect. Meanwhile, we also analyzed which kinds of doctor interaction behavior were beneficial to stimulate patient participation in value co-creation. Relevant strategies were proposed based on the analysis results. The value co-creation theory and the DART model provide guideline for doctors on how to interact with patients and patients on how to participate in value co-creation. Doctors can improve communication skills and deliver detailed information and give the chance for patients to participate in treatment discussions. For example, doctors can design treatments plans based on patients' needs and provide patients the opportunity to choose(Access); doctors encourage patients to follow treatment advice and inform the negative influence if not (Risk assessment); doctors tell patients about the reasons and costs if large-scale inspections need to be conducted or expensive medications need to be used (Transparency), which can help to stimulate patient participation in value co-creation. Meanwhile, patients should learn about health or medical knowledge actively to increase their health awareness and literacy and then empower themselves to participate in communication and discussion with doctors during treatment. However, this study has a few limitations. First, a large scale research or cohort study should be conducted to fully confirm the hypotheses and the relationship between doctor interaction behavior, patient participation in value co-creation, and patient satisfaction in the future study. As this research was a cross-sectional study and was confirmed based on a single tertiary-level hospital in Guangzhou, China, which cannot confirm the causal relationship. Second, we initially explored the relationship between doctor interaction behavior, patient participation in value co-creation, and patient satisfaction. However, it is possible that these three variables may interact with or exert a reverse influence on one another. In the future studies, more related variables could be included based on a systematic theoretical structure to explore their relationship fully, and representative items or measurement tools could be used to measure related variables systematically. Moreover, this study was primarily based on patient self-reported or self-perceived data. However, future research could also incorporate doctor self-evaluation to gain a more comprehensive understanding of the relationship between the variables and to reduce information or recall bias between patients and doctors.

Conclusion

Value co-creation emphasizes the participation and interaction of the suppliers and customers to reach an outcome that benefits both sides. Doctors and patients are the main participants during treatment. The participation and interaction of doctors and patients can result in an outcome that is beneficial to both sides. Doctors possess the advantage and authority of medical knowledge and technology, which affords them the capacity to provide professional guidance for their patients. It is recommended that they engage in active

interaction with patients, and encourage patient participation during treatment. Patient participation is essential for achieving optimal treatment effects. It is also an important part of co-create value with the doctor. Evidence about value co-creation is mainly conducted in the commercial field while in the healthcare field is limited. In this study, we introduced the concept of value co-creation and put forward the hypotheses to explored the relationship between doctor interaction behavior perceived by patient, patient participation in value co-creation, and patient satisfaction initially. The analysis result indicated that doctor interaction behavior could stimulate patient participation in value co-creation and then increase patient satisfaction. Furthermore, different kinds of doctor interaction behavior had different influence on patient participation in value co-creation, such as the behavior in the dimensions of access, risk-assessment, and transparency. Disease treatment is closely related to cooperation between doctors and patients. The collaboration between the two parties is conducive to enhancing the efficacy of the treatment.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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References

1. Normann, R. & Ramírez, R. From value chain to value constellation: Designing interactive strategy. *Harv. Bus. Rev.* **71** (4), 65–77 (1993).
2. Vargo, S. L. & Lusch, R. F. Evolving to a new dominant logic for marketing. *J. Market*. **68** (1), 1–17. https://doi.org/10.1509/jmkg.68.1.1.24036 (2004).
3. Prahalad, C. K. & Ramaswamy, V. Co-creating unique value with customers. *Strategy Leadersh.* **32**(3), 4–9. https://doi.org/10.1108/10878570410699249 (2004).
4. Prahalad, C. K. & Ramaswamy, V. The future of competition: Co-creating unique value with customers. *Cambridge, MA: Harvard Business School Press*.272 (2004).
5. McColl-Kennedy, J. R., Vargo, S. L., Dagger, T. S. & Sweeney, J. C. Kasteren,Y.V. Health care customer value cocreation practice styles. *J. Serv. Res.* **15** (4). https://doi.org/10.1177/1094670512442806 (2012), 370 – 89.
6. Li L.Research on co-creation of tourism experience value(in Chinese).Beijing:Tourism Education Press (2013).
7. Zhang, L., Hu, Z., Chen, S. & Li W.Health care management(in Chinese). *People's Med. Publishing House* 254–255 (2013).
8. Xu, J. & Prince, A. E. R.Shared decision-making in vascular surgery. *J. Vasc Surg.* **70**(5), 1711–1715. https://doi.org/10.1016/j.jvs.2019.03.002 (2019).
9. Tsai, Y. C. et al. The interaction between self-care behavior and disease knowledge on the decline in renal function in chronic kidney disease. *Sci. Rep.* **11**(1), 401. https://doi.org/10.1038/s41598-020-79873-z (2021).
10. Hau, L. N. & Tram, Anh, P. N. Thuy. P.N. The effects of interaction behaviors of service frontliners on customer participation in the value co-creation: A study of health care service. *Serv. Bus.* **11**(2), 253–277. https://doi.org/10.1007/s11628-016-0307-4 (2017).
11. Grönroos, C. Value co-creation in service logic: A critical analysis. *Mark. Theor.* **11** (3), 279–301. https://doi.org/10.1177/1470593111408177 (2011).
12. Baig, A. M. et al. Qualitative exploration of factors associated with shared decision-making in diabetes management: A health care provider's perspective. *Int. J. Qual. Health C.* **.32** (7), 464–469. https://doi.org/10.1093/intqhc/mzaa073 (2020).
13. Jaakkola, E. & Alexander, M. The role of customer Engagement Behavior in Value Co-creation: A service system perspective. *JSR.* **17**(3), 247–261. https://doi.org/10.1177/1094670514529187 (2014).
14. Yuan, N., Liu, C., Yu, L. & Song Q.Study process of patients involved in treatment decision-making state quo and influencing factors(in Chinese). *Med. Soc.* **30**(03), 58–61 (2017).
15. Ellingson, L. L. & Buzzanell, P. M. Listening to women's narratives of breast cancer treatment: A feminist approach to patient satisfaction with physician-patient communication. *Health Commun.* **11**(02), 153–183. https://doi.org/10.1207/s15327027hc1102_3 (1999).
16. Ye, X., Liu, Z. & Liu, X. Research on strategies for patient engagement in patient safety and its influencing factors (in Chinese). *Chin. J. Mod. Nurs.* **16** (35), 4217–4220 (2010).
17. Manzoor, F., Wei, L., Hussain, A., Asif, M., Shah, S. I. & Ali, & Patient satisfaction with health care services: An application of physician's behavior as a moderator. *Int. J. Environ. Res. Public. Health*. **16**(18), 3318. https://doi.org/10.3390/ijerph16183318 (2019).
18. Ganasegeran, K., Perianayagam, W., Abdul, M. R., Ali, Jadoo, S. A. & Al-Dubai S.A.R. Patient satisfaction in Malaysia's busiest outpatient medical care. *Sci. World J.* https://doi.org/10.1155/2015/714754 (2015).
19. Donabedian, A. Evaluating the quality of medical care. *Milbank Q.* **44** (03), 166–206. https://doi.org/10.2307/3348969 (1966).
20. Martin, L. R., Williams, S. L., Haskard, K. B. & Dimatteo, M. R. The challenge of patient adherence. *Ther. Clin. Risk Manag.* **1** (3), 189–199 (2005).
21. Sweeney, J. C., Danaher, T. S. & Mccoll-Kennedy, J. R. Customer effort in value cocreation activities: Improving quality of life and behavioral intentions of health care customers. *J. Serv. Res.* **18** (3), 1–18. https://doi.org/10.1177/1094670515572128 (2015).
22. Zhang, Z. Research on influential factors of customer participation in value co-creation—take the medical examination center of three public hospitals in Guangzhou as an example(in Chinese) [Unpublished master's thesis].*Southern Medical University* (2018).
23. Wei, Q. Study on influence mechanism of customer participation in value co—creation (in Chinese) [Unpublished master's thesis]. *Tianjin University* (2014).
24. Stein, T., Frankel, R. M. & Krupat, E. Enhancing clinician communication skills in a large health care organization: A longitudinal case study. *Patient Educ. Couns.* **58**, 4–12. https://doi.org/10.1016/j.pec.2005.01.014 (2005).
25. Makoul, G. The SEGUE Framework for teaching and assessing communication skills. *Patient Educ. Couns.* **45** (1), 23–34. https://doi.org/10.1016/s0738-3991(01)00136-7 (2001).
26. Hou, S. & Zhang, Y. Discussion on the main doctor-patient communication model and six-stage extended model (in Chinese). *Med. Philos.* **35**(01), 54–57 (2014).
27. Wang, C. Discussion on some important issues in quality of life research (II) (in Chinese). *Chin. J. Behav. Med. Sci.* **8**(2), 155–157 (1999).
28. Wang, D., Xing, X. & Wu, X. The healthy lifestyle scale for university students: development and psychometric testing. *Aust J. Prim. Health*. **18**(4), 339–345. https://doi.org/10.1071/PY11107 (2012).
29. Mai, S., Su, S. & Wang, D. Patient value co-creation behavior scale based on the DART model. *Am. J. Manag Care.* **26**(09), e282–e288. https://doi.org/10.37765/ajmc.2020.88493 (2020).

30. Mai, S. & Wang, D. Doctor interaction behavior evaluation scale based on dart model [in Chinese]. *Mod. Prev. Med.* **49** (13), 2486–2491. https://doi.org/10.20043/j.cnki.MPM.202110107 (2022).
31. Hojat, M. et al. Physician empathy: definition, components, measurement, and relationship to gender and specialty. *Am. J. Psychiatry*. **159** (9), 1563–1569. https://doi.org/10.1176/appi.ajp.159.9.1563 (2002).
32. Hojat M. Empathy in patient care: Antecedents, development, measurement, and outcomes. Springer: 100–102. (2007).
33. Hayes, A. F.Introduction to mediation, moderation, and conditional process analysis (Second Edition). *New York, The Guilford Press* (2018).
34. Wood, M. Bootstrapped confidence intervals as an approach to statistical inference. *Organ. Res. Methods*. **8** (4), 454–470. https://doi.org/10.1177/1094428105280059 (2005).
35. Yuan, N., Liu, C., Yu, L. & Song, Q. Status quo of participation of surgery patients in surgical decision-making and its influence factors (in Chinese). *J. Nurs.* **24** (04), 47–50. https://doi.org/10.16460/j.issn1008-9969.2017.04.047 (2017).
36. Wei, Q. Research and empirical analysis of the impact mechanism of value co-creation based on customer experience(in Chinese). *Hebei J. Industrial Sci. Technol.* **30**(06). https://doi.org/10.7535/hbgykj.2013yx060 (2013), 407 – 413.
37. Willging, A. M., Castro, E. & Xu, J. Physician-patient communication in vascular surgery:analysis of encounters in academic practice. *SAGE Open. Med.* **10**, 20503121221122414. https://doi.org/10.1177/20503121221122414 (2022).
38. Phelan, A., McCormack, B. & Dewing, J. Review of developments in person-centred healthcare. *IPDJ*. **10**https://doi.org/10.19043/ipdj.10Suppl2.003 (2020).
39. Kylén, M., Schön, U., Pessah-Rasmussen, H. & Elf M.Patient participation and the environment:a scoping review of instruments. *Int. J. Environ. Res. Public. Health*. **19**(4). https://doi.org/10.3390/ijerph19042003 (2022).
40. Li, C. et al. Y.Questionnaires measuring patient participation in patient safety-a systematic review. *J. Nurs. Manag.* **30** (7), 3481–3495. https://doi.org/10.1111/jonm.13690 (2022).
41. Osei-Frimpong, K., Wilson, A. & Lemke, F. Patient co-creation activities in healthcare service delivery at the micro level: the influence of online access to healthcare information. *Technol. Forecast. Soc.* **126**, 14–27. https://doi.org/10.1016/j.techfore.2016.04.009 (2018).
42. Goodworth, M. C. et al. Variables associated with patient activation in persons with multiple sclerosis. *J. Health Psychol.* **21**(1), 82–92. https://doi.org/10.1177/1359105314522085 (2016).
43. Bonsaksen, T., Fagermoen, M. S. & Lerdal, A. Trajectories of self-efficacy in persons with chronic illness: An explorative longitudinal study. *Psychol. Health*. **29**(3), 350–364. https://doi.org/10.1080/08870446.2013.856432 (2014).
44. Li, Z. & Liu H.An empirical study of medical service attitudes of doctor (in Chinese). *Med. Philos.* **35**(10), 41–45 (2014).
45. Tan, G., Fen, Z., Chen, L. & H R. & Zhao, R. Study of the requirement of the obstetrical customers about non-technical quality service based on quality function deployment [in chinese]. *Chin Hosp Manag.* **31**(05), 29–31. http://en.cnki.com.cn/Article_en/CJFDTOTAL-YYGL201105015.htm (2011).
46. Sun, C. et al. New doctor-patient communication learning software to help interns succeed in communication skills. *BMC Med. Educ.* **20**(1), 8. https://doi.org/10.1186/s12909-019-1917-z (2020).
47. Sekar, D. R., Siropaides, C. H., Smith, L. N. & Nguyen, O. K. Adapting existing resources for serious illness communication skills training for internal medicine residents. *South. Med. J.* **114** (5), 283–287. https://doi.org/10.14423/SMJ.0000000000001247 (2021).
48. Groopman, J. & Hartzband, P. Your medical mind: Hw to decide what is right for you. *Enguin Press* (2011).

Author contributions

SMM and DW had the original idea for the analysis. SMM was responsible for retrieving and organizing literature, conducting the survey, completing statistical analyses, and drafting and revising the first manuscript. DW participated in the design and coordination of the study. LC, Richard HX, SWS, and DW helped to modify articles. All authors have read and approve the final manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Additional information

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